D 9	Bit Error Rate B.E.R.	Only reference value: 10^{-6}	-
D 10	Wake-up process for OBU	Wake-up process on ordinary data.	-
D 10a	Maximum Start Time	≤ 5 ms	-
D 11 (*)	Power Limits within Communication Zone	Min. incident power: -40 dBm Max. incident power: -14 dBm	-
D 13	Preamble	Preamble is mandatory	-
D 13a	Preamble Length	16 bit ± 1 bit	-
D 13b	Preamble Waveform	An alternating sequence of low level and high level with pulse duration of 2 µs.	-

(*) - Downlink parameters subject to Type Approval. Refer to explanation above.

4.2 Uplink Parameters

Table 2 defines relevant uplink DSRC Layer 1 parameters. Initialisation of any communication shall be performed by using the given default values. On-line negotiations, performed by higher DSRC layers, may result in utilisation of options values.

The parameters which have been marked with an asterisk (*) are subject to legal type approval requirements. These parameters are specified in ETSI standard prI-ETS 300 XXX. Equipment meeting the requirements of the ETSI standard shall simultaneously satisfy the comparable requirements of this CEN standard. Therefore these parameters have the same value in each standard.

The parameters marked with an asterisk (*) have been set by mutual agreement between ETSI and CEN to achieve efficient use of the radio spectrum and acceptable performance for a short-range communication link, together with other performance requirements set out in this CEN standard. These parameters cannot be changed by either ETSI or CEN without the simultaneous agreement of each organisation.

Table 2: Uplink parameters

Item no.	**Parameter**	**Values**	
		Default	**Options**
U 1 (*)	Sub-carrier Frequencies	1.5 MHz and 2.0 MHz	Defined by installation and due to negotiations.
U 1a	Tolerance of Sub-carrier Frequencies	within ± 0.1%	-

U 1b	Use of Side Bands	Same data on both sides or data only on upper side band will be allowed for default	Both side bands can be used independently. There are four possibilities coded as follows: 00 Reserved for future use 01 Same data in both sidebands 10 Data only in upper sideband 11 Different data in sidebands.
U 1c	Tolerance of Direct Generated Uplink Carrier	same as D1a	-
U 2 (*)	OBU Transmitter Spectrum Mask	All values referred to outside the vehicle. (1) Out band power: $\leq$ -30 dBm in 1 MHz (2) In band power: (adjusted) $\leq$ -24 dBm in 500 kHz (3) Spurious emission in any other uplink channel: -42 dBm in 500 kHz	-
U 3	RSU Minimum Receiver RF Bandwidth	CEPT-band 5.8 GHz $\pm$ 5 MHz	National band within same ISM band
U 4 (*)	Maximum Single Sideband E.I.R.P.	$\leq$ -24 dBm	-
U 5 (*)	Antenna Polarization	Left hand circular	-
U 5a	Cross Polarization	XPD: In boresight: $RSU_r \geq 15$ dB $OBU_t \geq 10$ dB At -3 dB: $RSU_r \geq 10$ dB $OBU_t \geq 6$ dB	-

U 6	Sub-Carrier Modulation	M-PSK Encoded data synchronised with subcarrier: Transitions of encoded data coincide with transitions of subcarrier.	-
U 6a	Data Modulation Order	M=2	Defined by installation and due to negotiations. 2 bit coded: 00 M = 2 01 M = 4 10 M = 8 11 reserved for future use
U 6b	Eye Pattern / Duty Cycle	Eye pattern: $\geq 90\% / \geq 90\%$; or Duty Cycle: $50\% \pm \alpha$, $\alpha \leq 5\%$	-
U 6c	Modulation on Carrier	Multiplication of modulated sub-carrier with carrier.	-
U 6d	Side Band Suppression	≥ 60 dB	-
U 6e	Side Band Isolation	≥ 20 dB	-
U 7 (*)	Data Coding	NRZI (No transition at beginning of "1" bit, transition at beginning of "0" bit, constant level within bit)	-
U 8 (*)	Symbol Rate	250.000 baud	Defined by installation (and due to negotiations): Bit rate coded in 3 bit: 000 reserved for future use 001 31.25 kBit/s 010 62,5 kBit/s 011 125 kBit/s 100 250 kBit/s 101 500 kBit/s 110 750 kBit/s 111 reserved for future use (Every symbol rate has to comply with U2)

U 8a	Tolerance of Symbol Clock	0.1 % of used symbol rate	-
U 9	B.E.R.	Only reference value: 10^{-6}	-
U 11	Power Limits within Communication Zone	The CW Power produced by the RSU which allows the reference OBU defined by U12 to have a transmit power E.I.R.P. of a sufficient level to allow the RSU to receive with a B.E.R. not exceeding reference value defined by U9.	-
U 12 (*)	Minimum Conversion Gain	-5 dB for each used side band Range of angle: Circularly symmetric around bore sight $\pm 35^{o}$	-
U 13	Pre-/Postamble	Preamble is mandatory	-
U 13a	Preamble Length and Pattern	32 ... 40 µs modulated with subcarrier only, then 8 BPSK symbols with a phase shift at the beginning of every symbol.	-
U 13b	Postamble Length and Pattern	2 symbols of 1 bits in the chosen M-PSK mode + further 6 symbols to switch off and decrease the power level at least by 40 dB. The decreased power level has to be acheived at any time during these 6 further symbols.	-

(*) - Uplink parameters subject to Type Approval. Refer to explanation above.

4.3 Interface Parameters to DSRC Data Link Layer

Table 3: Interface Parameters, relevant for communication with DSRC Data Link Layer

Item number	**Parameter**	**Values** **Default**	**Options**
D 14a	$RLTA_{rt}$	Length of preamble for downlink + 1 bit	-
D 14b	$OLTA_{tr}$	100 bit	-
U 14a	$OLTA_{rt}$	Length of preamble for uplink + 1 bit	-
U 14b	$RLTA_{tr}$	100 bit	-
D 22	Minimum Frame Length for OBU Wake-Up	12 Byte	-
D 22a	OBU Time-Out	100 ms subject to acceptance by higher layers	

5 ANNEX

5.1 Annex A: Bibliography (Informative)

Table A1: Documents, served as references while preparing the standard

No.	Author(s)	Title
1	CEPT	"Procedures for Type Testing and Approval for radio equipment intended for non-public systems", CEPT Rec. T/R 71-03 E, 15.04.91.
2	ERC/CEPT	"Harmonisation of frequency bands for Road Transport Informatics Systems (RTI)", CEPT Rec. T/R 22-04E, Lisbon 1991.
3	ERC/CEPT	"Harmonisation of frequency bands to be designated for Road Transport Telematics Systems", ERC Report 3.

Table A2: Documents, which can provide further insight into the evolution of the standard

No.	Author(s)	Title
I-1	CEN TC278 WG9	"1st Status Report to CEN / TC278", CEN TC278 WG9 doc. #35, April 3, 1993
I-2	H J Fischer, DASA (editor)	"DSRC - 5.8 GHz Layer 1, First Report to CEN TC278", CEN M018 PT06, doc. 2-25, 25. July 1994
I-3	H J Fischer, DASA (editor)	"Document Register", CEN M018 PT06, doc. 2-1, Version 1.8, 29.07.94.

5.2 Annex B: Installation and re-use distance of DSRC equipment (Informative)

To enable interoperability between different DSRC equipment fulfilling the requirements of this Pre-Standard, it is believed to be necessary to consider also the installation requirements. Such installation requirements may distinguish between different RTTT applications. Considering e.g. Automatic Fee Collection or Automatic Vehicle Identification, the OBU antenna could be installed in the centre of the vehicle, possibly behind the rear mirror. The direction of the OBU antenna should be matched to the intended configuration of the DSRC communication zone.

The installation geometries to some extent also influence the aspect of minimum re-use distance between independent, non-synchronized communication channels caused by interference. The re-use distance is also dependent on specific implementation parameters such as RSU antenna gain and RSU transmitter spectrum mask class (Section 4.1, Requirement D2). In the preparation of this Pre-Standard, re-use distances were calculated using a free-space propagation model, even though under specific circumstances shorter re-use distances may be attained

As an illustration of the free-space model prediction results, Table B1 below shows calculated non-synchronized re-use distances based on the following assumptions:

(1) The RSU transmits with maximum E.I.R.P. (see parameter D4).

(2) The OBU transmits with maximum E.I.R.P. (see parameter U4).

(3) The maximum allowed interference level for uplink receiver is -135 dBm (assuming RSU antenna gain of approximately 20 dB).

(4) The RSU antenna provides a sidelobe suppression of 15 dB.

(5) The maximum allowed interference level for the downlink receiver is - 60 dBm.

Based upon these assumptions and free-space propagation, calculated re-use distances for the three classes of RSU transmitter spectrum mask are presented in Table B1.

Table B1: Calculated re-use distances

Interference path	Class A	Class B	Class C
Downlink on uplink			
co-channel at 1.5 MHz	330 m	105 m	35 m
co-channel at 2.0 MHz	35 m	35 m	35 m
adjacent channels	25 m	10 m	3 m
Downlink on downlink			
same channel		35 m	
other channel		negligible	
Uplink on uplink			
same channel		260 m	
other channel		35 m	
Uplink on downlink		negligible	

5.3 Annex C: Link budget related parameters (Informative)

In the preparation of this Pre-Standard, link budget related parameters were defined in a way to make them independent of application specific conditions. Specifically in RTTT applications, values given for the following parameters should be referred to the outside of the vehicle:

D 11: Communication Zone

U2: OBU Transmitter Spectrum Mask

U4: Maximum Single Sideband E.I.R.P.

U11: Communications Zone.

U12: Minimum Conversion Gain.

Relevant attenuation factors have to be considered in each particular case in order to comply with these parameter specifications.

As an example, the following calculations were made in the case of parameter U12 Minimum Conversion Gain:

Table C1: Conversion Gain Budget

OBU antenna gain 35 degrees off boresight.	4 dB
Windscreen loss, one way	3 dB
Loss per sideband	3 dB
Realisation margin (OBU losses, manufacturing tolerances...)	4 dB

In this example the resulting minimum conversion gain, calculated as two times the OBU antenna gain minus two times the windscreen loss minus OBU losses will be -5 dB for each side band, as specified in U12.

Attachment 4 to Appendix L

RTTT's DSRC Standard using Microwave in Japan (26 September, 1996)

26 September. 1996

REV.4

RTTT's DSRC Standard using Microwave in Japan

This document has been prepared by ISO/TC204/WG15 Committee of Japan for submission to the following international meetings:

(1) 01-02 Oct. 1996, CEN/TC278/WG9 Munich Meeting

(2) 09 Oct. 1996, ISO/TC204/WG15 Orlando Meeting

01-02 October 1996
CEN/TC278/WG9 (DSRC)
and
09 October 1996
ISO/TC204/WG15 (DSRC)

ISO/TC204/WG15
Committee of Japan

1. ITS Research and Development in Japan

Intelligent Transport Systems (ITS) in Japan, a project to establish systems for integrating people, roads and vehicles by means of advanced information and telecommunication technologies, is considered an effective solution to problems such as traffic accidents, traffic jams and environmental hazards.

In February 1995, the "Advanced Information and Telecommunications Society Promotion Headquarters," established by the Japanese government, provided "Basic Guidelines on the Promotion of Advanced Information and Telecommunications Society," which decided on the constructive promotion of ITS in Japan.

Also, in August 1995, the five ministries*1 concerned, including MPT, provided Guidelines on the Increasing Use of Information and Communications" and defined nine development areas as shown in Fig. 2.

The development and nationwide prevalence of ITS is expected to create new markets, estimated to amount to as much as 50 trillion yen (US$470 billion) in the automotive, and information and communication industries (VERTIS's estimate).

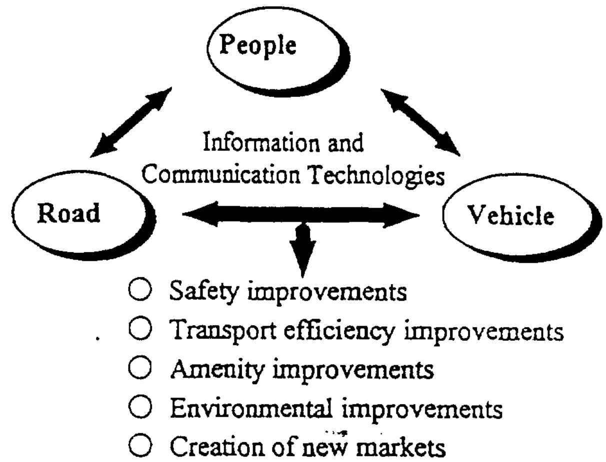

Fig-1 Model on People, Roads and Vehicles

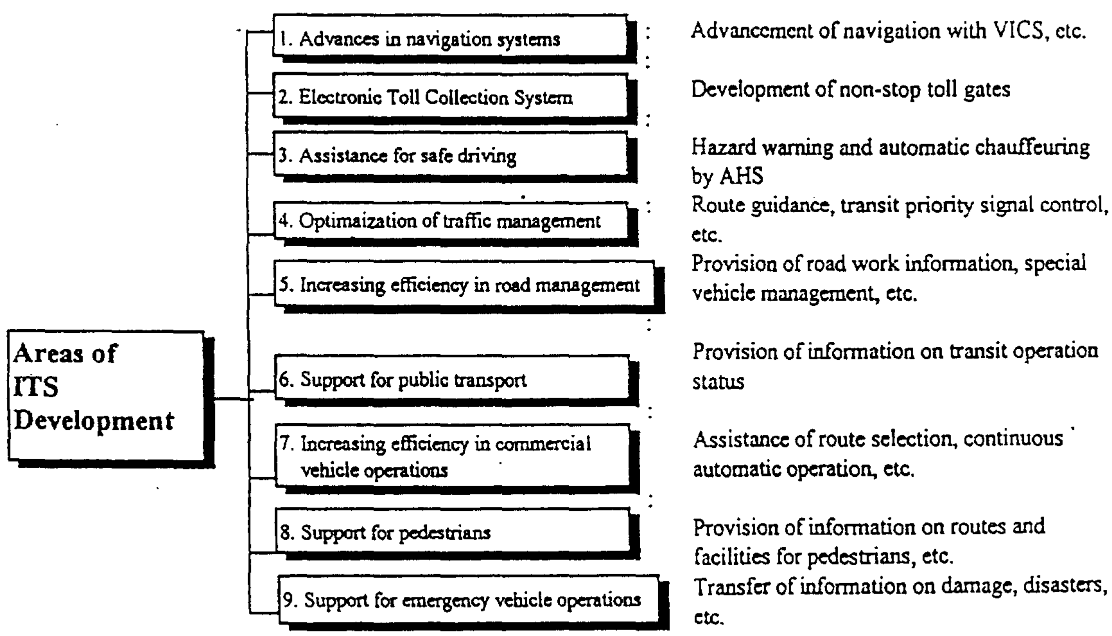

Fig-2 Nine Development Areas of ITS in Japan

*1 ; The National Police Agency (NPA), The Ministry of Posts and Telecommunications (MPT), The Ministry of International Trade Industry (MITI), The Ministry of Transport (MOT), The Ministry of Construction (MC)

2. Measures to Be Taken in Japan

Implementation and infrastructure development as well as overall promotion of research and development are proposed as measures to be taken in the nine ITS development areas in Japan.

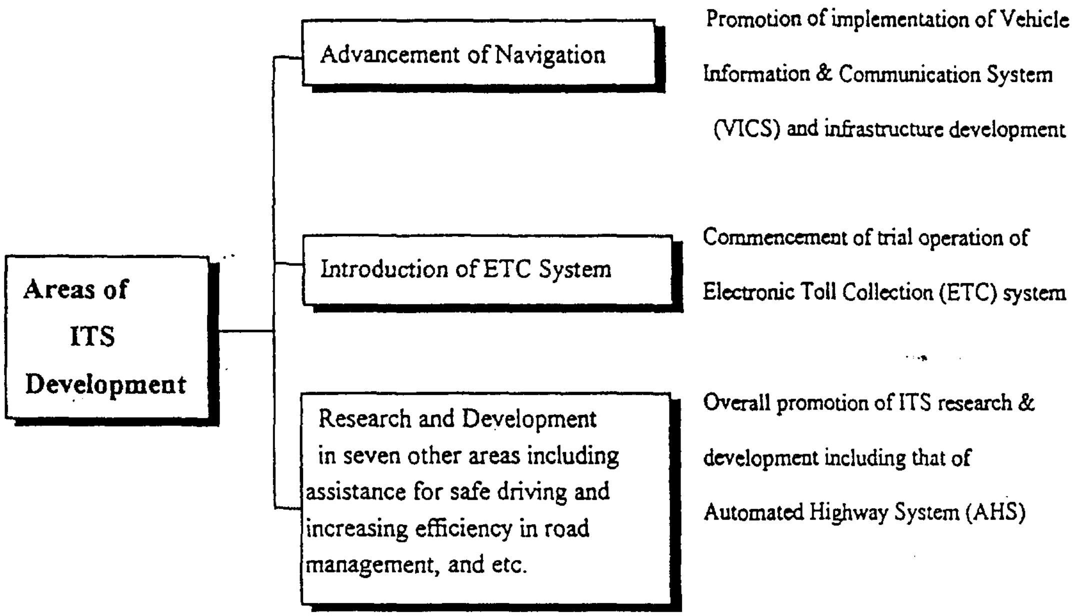

Fig-3 Measures at Present

2.1 Putting VICS into Practical Use and Promoting Infrastructure Development

a. A service using microwave, infrared radiation and FM wave for providing real-time information such as congestion information, required travel time, road construction / maintenance work information and traffic control information to on-board units (navigation system, etc.) has started in metropolitan area, Tokyo-Nagoya Expressway, and Nagoya-Kobe Expressway since April 1996 ahead of other systems.

b. It is also planned to implement information processing infrastructure including beacons, etc. in countrywide expressways with an aim to start information providing services in these areas in 1997. The implementation of infrared beacons allowing two-way communication is planned to be further developed to cover ordinary roads in major cities.

c. As an expansion of this system, development concerning advancement of navigation systems including implementation of infrastructure for two-way communication with on-board units and research concerning improvement of visibility, operability and legibility of on-board units will be promoted by utilizing the two-way communication already implemented.

2.2 Introduction of ETC System

a. The ETC system, using two-way Vehicle-to-Roadside Communications (VRC), enables drivers on toll roads to pay their tolls without stopping at toll gates.
b. To establish a system suitable for Japanese toll roads, ten consortiums consisting of twenty-two private companies including foreign companies, the Ministry of Construction and four highway public corporations carried out a joint research from June 1995 to March 1996. The cost concerning the joint research amounts to about 3 billion yen (US$ 29 million).
c. It is planned that trial operations of the ETC system will start in 1997, with a view to its future implementation. These trials will ensure reliable communications at toll gates and safe traffic behavior of vehicles.
d. The ETC system is expected to be first implemented in 1999 and its application to all roads nationwide is expected to be completed in the several succeeding years.

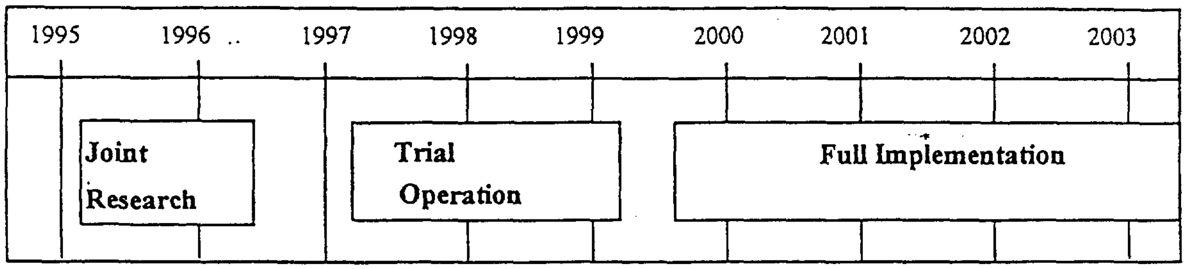

Fig-4 ETC System Development in Japan

2.3 Development of Safe Driving Assisting Systems (Assistance for safe driving)

a. The safe driving assisting system covers providing travel environment information for assisting safe driving to automated driving and driving assistance for the aged and physically handicapped persons.
b. With regard to the ASV (Advanced Safety Vehicle) applied with electronics technologies, establishment of technical guidelines, prototype vehicle development and driving test have so far been completed. In the SSVS (Super Smart Vehicle System) for close contacts between vehicles for coordinated adjustment of vehicle behaviors, necessary information is planned to be exchanged through the data link network in the varying vehicle group by using infrared ray or millimeter wave.
c. The communication system between the road and vehicle sides through the roadside system and Vehicle-to-Vehicle communication system shall be developed by integrated functional development for system development.

3. Two-way Communication by Microwave DSRC

The two-way DSRC using the microwave in Japan for the Vehicle-to-Roadside Communications (VRC) is planned to be introduced with the ETC system as the forerunner, and developed further to cover other ITS applications.

This draft outlines the experiment and specifications of the two-way DSRC using microwave in Japan. Detailed specifications will be submitted for the next conference and on.

3.1 DSRC System Experiment

Research and development of the leading ETC system have been conducted jointly with private companies with regard to the radio communication, toll collection and lane traffic control technologies. The outline of the joint study for radio communication technologies are as follows. The detailed contents are described in the Annexes.

a. The toll road traffic network so far established amounts to 7,200 km in total. It is necessary to cover both per-distance and flat rate system roads. Since about ten routes should be checked, the amount of basic information is large.

b. Since high-amount settlement (about US$700) is necessary in some cases, the reliability of the ETC system should be higher than that of the existing (cash collection) system. It should at least be about 10^{-6}.

c. At least two communication zones are required per lane at the toll gate for linkage with the vehicle type identification system and for IC card writing confirmation. The radio communication distance per communication zone is about 6 m.

d. At a toll gate involving high possibility of congestion, it is necessary to guide vehicles with faulty on-board units to ordinary lanes in order to ensure efficient management of exclusive ETC lanes. They are guided by approach antennas before the gate. The distance covered by the approach antenna is about 30 m.

e. A protocol for simultaneous communication with up to two vehicles per lane is required on assumption of motor cycles running in parallel, and the same with up to 3 or 4 vehicles is required on assumption of two lanes as a communication zone for the free-flow lane type.

f. The theoretical equation for the propagation loss characteristic is also applicable to toll gates with the structure for short-distance communication conditions.

g. The C/N characteristic of the on-board unit is worse by several dB than the theoretical value.

h. The result of city noise evaluation tests shows much noise from the ISM equipment in the 2.5 GHz band.

i. A propagation margin in one direction should be about 10 dB because of the influence of the window glass and wiper of the vehicle.

j. The maximum amount of information per one communication zone is about 4,000 bits.

k. As a result of traveling test of about 9,000 vehicles, no radio communication error occurred.

3.2 DSRC Physical Specifications

The engineering standards for DSRC physical specifications have been studied based on the experimental results and system conditions of the joint research. Table 1 outlines the specifications under study.

Table 1 Physical Specifications of DSRC Using Microwave

Parameter	Specification
Radio frequency band	5.8 GHz band (ISM band)
Communication system	Active transceiver system Roadside equipment: Full-duplex communication On-board unit: Half-duplex communication
Modulation system	A1D (ASK)
Coding system	FM0 or Manchester
Data transmission rate	1 Mbps (radio modulation rate: 2 M baud)
Allowable occupied bandwidth	8MHz/CH
Required bandwidth	10MHz x 4 (2 pairs of waves for transmission and receiving)
Receiving sensitivity	Roadside equipment: -75 dBm or less On-board unit: -60 dBm or less
Transmission output	Roadside equipment: 10 mW or less (communication distance at about 6 m) 300 mW or less (communication distance at about 10 to 50 m) On-board unit: 10 mW or less
Antenna gain	Roadside equipment: 20 dBi or less On-board unit: 10 dBi or less
Antenna polarization	Circular polarization

With regard to the radio communication specifications, these values will be applied not only to the electronic toll collection system (ETC) but to the road traffic and traveller information system (TTI), specific vehicle management system, commercial vehicle operation system (CVO) and emergency information system to establish compatibility between these systems.

Adoption of the transponder system is studied for the simple automatic vehicle identification system (AVI) and automatic equipment identification system (AEI).

3.3 DSRC Protocol

Adoption of the slotted aloha system is studied to enable simultaneous communication with multiple vehicles possible.

a. Frame format

The frame format is made variable depending on the communication zone size with the slot length being fixed in consideration of the full duplex communication. The bit count for a frame length is an assumed value being studied

(1) Lane-based frame

Communication with up to two on-board units is possible.

(2) Open-road frame

Communication with up to four on-board units is possible.

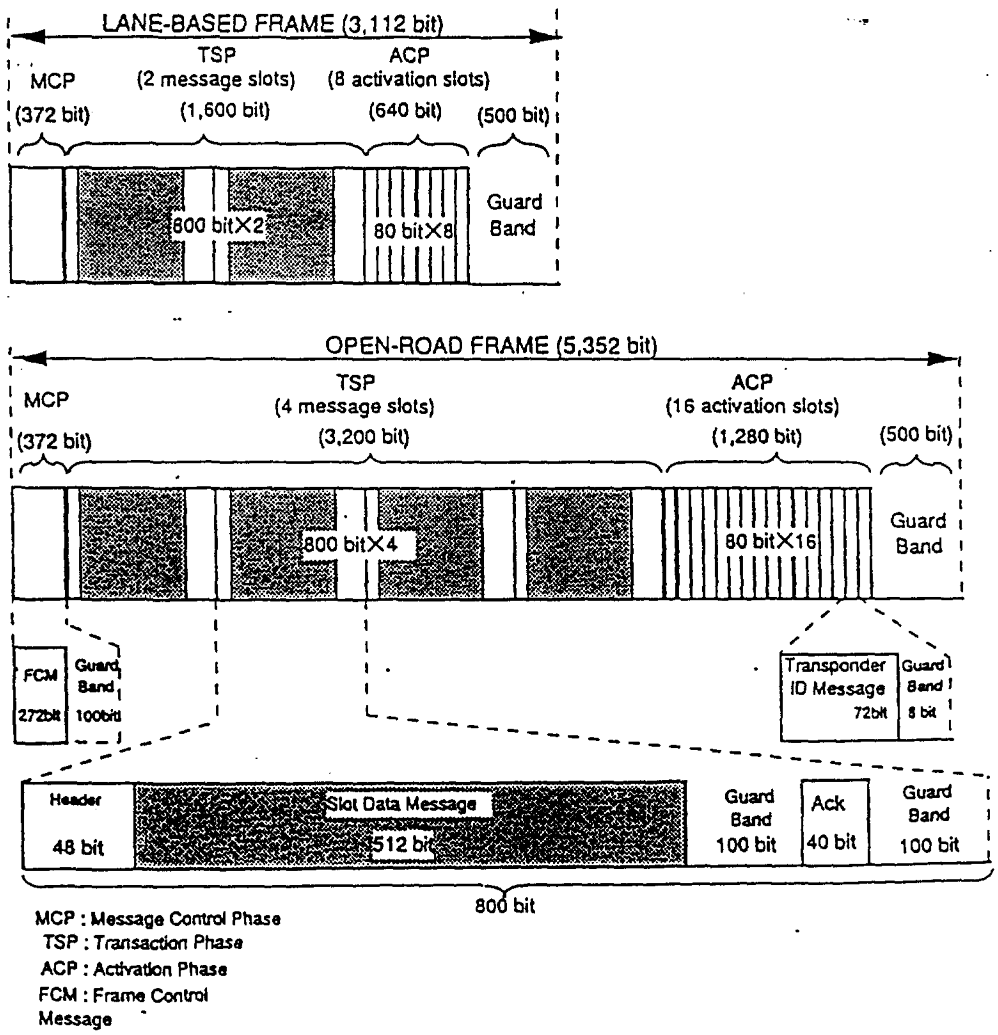

Fig-5 Frame Structure

b. Function of each phase in frame

(1) MCP (Message Control Phase)

Frame synchronization, message slot allocation, processing type and so forth are instructed by the FCM to the on-board unit for communication control by the roadside equipment.

(2) TSP (Transaction Phase)

Slot data messages are transferred. Ack or Nack is returned upon reception of each message.

(3) ACP (Activation Phase)

The on-board unit entering the communication zone and receiving the FCM selects one activation slot at random for registration request to send the on-board unit ID (identification code) to the roadside equipment.

c. Explanation on Transaction

(1) Transactions until Slot Data Message Allocation

① The on-board unit receives the FCM upon entering the communication zone.

② The on-board unit receiving the FCM selects an arbitrary slot of the Activation Phase and transmits the on-board unit ID.

③ The roadside equipment allocates a slot data message to the on-board unit according to the request form the on-board unit, and transmits the result by means of the FCM.

④ The on-board unit performs data transmission/reception by means of the slot data message allocated by the FCM.

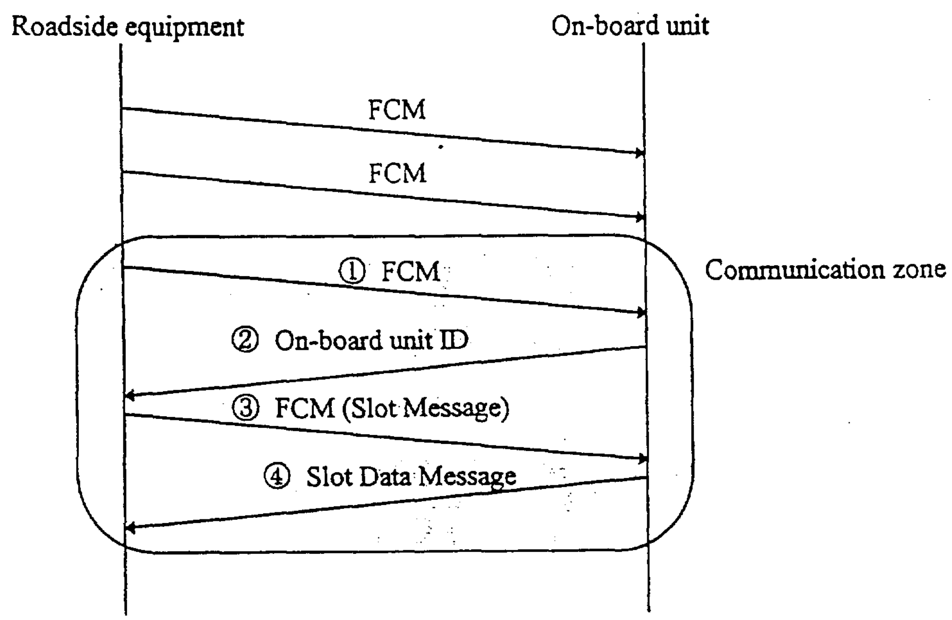

Fig-6 Time Chart

(2) Consideration for Full Duplex Communication

The communication efficiency can be improved further by adopting full duplex communication for the roadside equipment. The transactions for simultaneous control of the slot data message uplink and downlink by the roadside equipment are illustrated below.

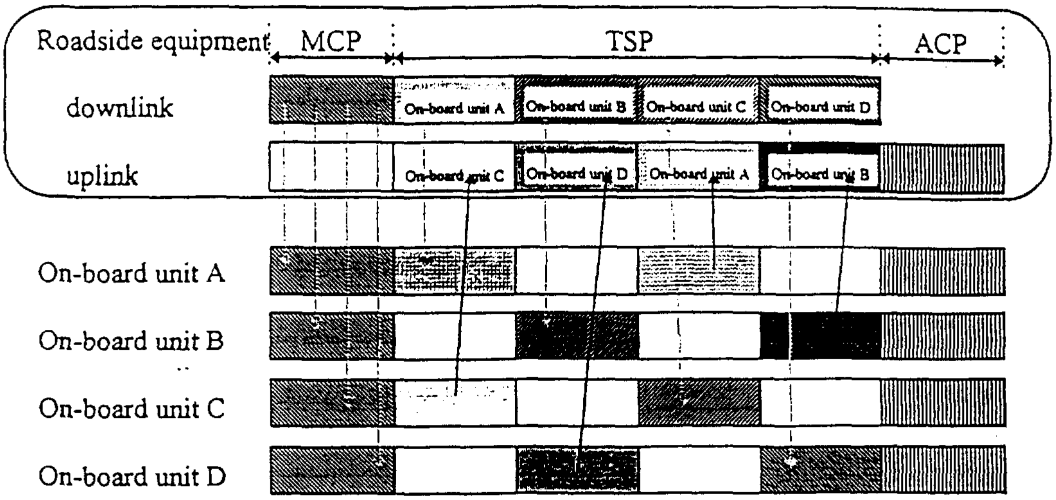

Fig-7 Transaction

d. Study on Frame Format

The following study has been conducted for high-efficiency communication matching each of various possible ITS applications:

(1) Study on controlling the number of slots

Enabling high-efficiency communication by changing the number of slots among 0, 1, 2, 4 and 8 for the TSP and among 0, 1, 2, 4, 8 and 16 for the ACP as desired for each application.

(2) Study on ACP layout considering full duplex communication

The communication efficiency can be improved further in the case of full duplex communication on the roadside equipment side by shortening the overall frame length by placing the ACP and TSP on the downlink side when the uplink TSP is not in use.

4. Adaptation to International Standard

As described in section 3, the Japanese DSRC specifications which we are studing are different from the draft currently studied by CEN/TC278/WG9.

It does not mean that we in Japan reject the CEN draft. It is possible that the techniques and methods of the road traffic information system vary with each region or country. In discussing the international standard (ISO), unification is unnecessary. Multiple standards may exist for various individual systems so as to allow selection for each country or region.

Japan desires to cooperate in preparing a part of multiple international standards.

4.1 Classification of International Standards

Table 2 shows classification of DSRC standards being studied for communication between road and vehicles. Those with Document No. among these are the draft standards prepared by the CEN subject to NP voting this time. As regards the DSRC, multiple standards should exist since the media, transmission rate and protocol vary with the application.

Japan is prepared to cooperate in preparing the draft for standards marked "JPN" in the table.

Table 2 DSRC Standard Classification

Document No.	Standard	Main system	Preparation
＊＊＊＊＊＊	DSRC Layer 1 LDR	Radio wave transponder system	CEN
CEN TC278 N473	DSRC Layer 1 MDR	Radio wave transponder system	CEN
CEN TC278 N526	DSRC Layer 1 IR	Infrared radiation system	CEN
＊＊＊＊＊＊	DSRC Layer 1 HDR	Radio wave transceiver system	JPN
＊＊＊＊＊＊	DSRC Layer 1 For LCX	Radio wave transceiver system	JPN
＊＊＊＊＊＊	DSRC Layer 1 For SC*1	Infrared radiation system	JPN
CEN TC278 N474	DSRC Layer 2	Half-duplex communication system	CEN
＊＊＊＊＊＊	DSRC Layer 2 HDR	Full duplex communication system	JPN
＊＊＊＊＊＊	DSRC Layer 2 For LCX	Full duplex communication system	JPN
＊＊＊＊＊＊	DSRC Layer 2 For SC*1	Full duplex communication system	JPN
CEN TC278 N505	DSRC Layer 7	Half-duplex communication system	CEN
＊＊＊＊＊＊	DSRC Layer 7 HDR	Full duplex communication system	JPN
＊＊＊＊＊＊	DSRC Layer 7 For LCX	Full duplex communication system	JPN
＊＊＊＊＊＊	DSRC Layer 7 For SC*1	Full duplex communication system	JPN

(*1 ; one to one spot communication)

4.2 *Relationships with ITU*

The TICS standard is being studied by ITU-R/SG8/WP8A. Since the DSRC standard is partially duplicated with the ITU-R, sufficient coordination with ISO/TC204 is necessary. Therefore, the part of the DSRC standard being studied and planned to be recommended by the ITU should conform to ITU recommendations.

ANNEXES

ANNEX A. Toll Roads in Japan

The development of the expressway network in Japan has been half completed. The expressways provided by the four highway public corporations (The Japan Highway Public Corporation, The Metropolitan Expressway Public Corporation, The Hanshin Expressway Public Corporation and The Honshu-Shikoku Bridge Authority), extending for approximately 7,200 km altogether, are currently in service. Also toward the final development goal of 13,000 km, expressways extending for 200 to 300 km will be completed and come into service every year. (See Fig. A1.)

This expressway network, together with 234 toll roads run by regional highway public corporations and private companies, provide arterial roads for Japanese industries and tourism.

For expressways that are already in service, a large-scale toll collection network has been formed. At all toll gates at the interchanges, divided lanes are provided and booths, roofs and other facilities are constructed for collection personnels and collecting equipment on all lanes.

Fee income from expressways per day totals about 6 billion yen (US$57 million) and the average number of vehicles using these expressways daily is 7.2 million.

ANNEX B. ETC System Conditions

B.1 Introduction of ETC Systems after Formation of Toll Road Network

The introduction of early ETC systems into the current type of toll collection operation (lane-based operation) must be planned in such a way as to allow future development to the free-flow type. In other words, a suitable method must be employed to ensure transition from individual communication with each vehicle within a three-meter lane width to wireless communications with vehicles in free-flow traffic in two to three lanes.

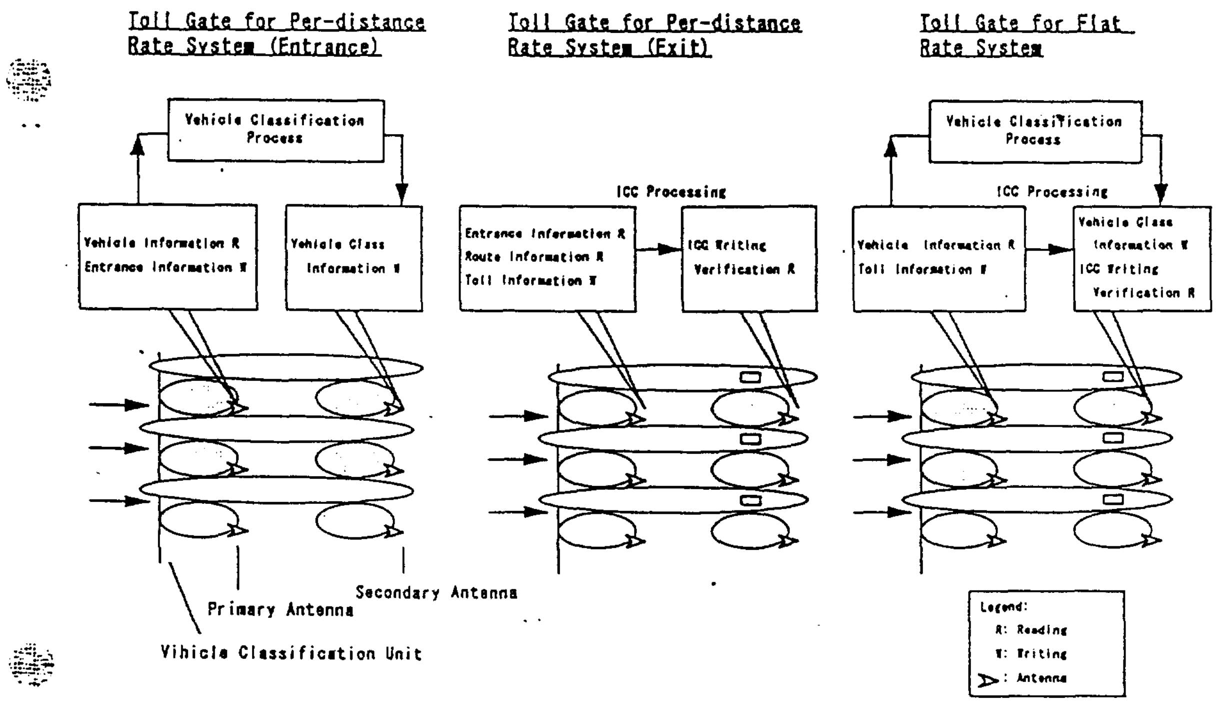

Fig-B1 Communication Zones for Toll Gate Antennas

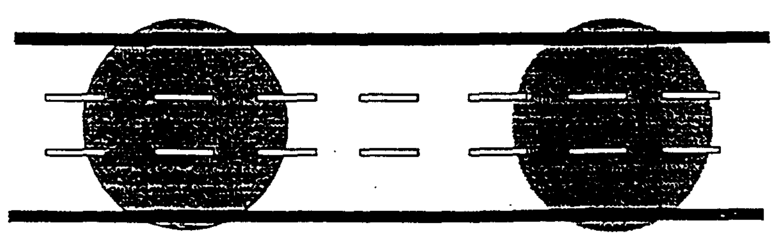

Fig-B2 Communication Zones for Free-flow Antennas

B.2 Introduction of "Approach Antenna" for vehicle Navigation at Toll Gates

Due to traffic congestion at toll gates caused by heavy traffic volume on toll roads in Japan, there are many toll gates where users complain to the authorities. Therefore, the most important requirement is to guide vehicles smoothly and safely at toll gates by means of implementation of ETC systems.

To reach that goal successfully, "Approach Antennas" are required to guide and distinguish vehicles equipped with on-board unit (OBU), and to identify such vehicles in advance as well as vehicles with OBU faults such as expired IC cards, IC cards with insufficient balance, or without IC cards, and guide them to manned lanes (non-ETC lanes).

As shown in Fig. B3, this "Approach Antenna" will guide vehicles with OBU to ETC-dedicated lanes by means of wireless communications between the roadside equipment and OBUs on the vehicles in the approach zone of the toll gate, thus enhancing the efficiency of the ETC-dedicated lanes and eliminating traffic congestion at toll plazas.

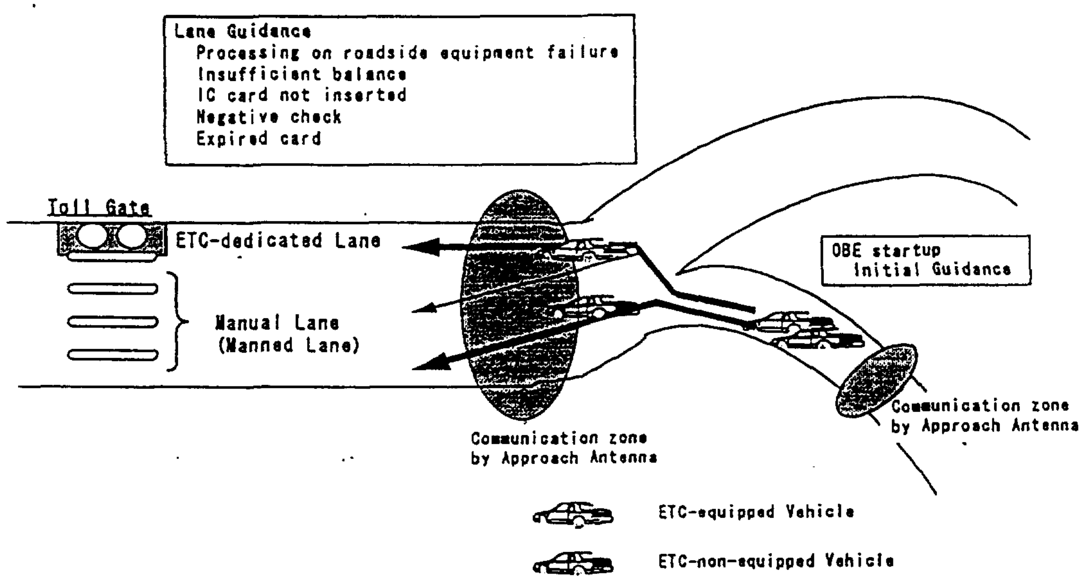

Fig-B3 Communication Zones by Approach Antenna

B.3 Per-distance Rate System and the Need for Route Recognition

The inter-urban expressways employ a large-scale distance rate system with service section extension of 5,930 km as of April 1996. The road network is complicatedly interconnected as shown in Fig. B4.

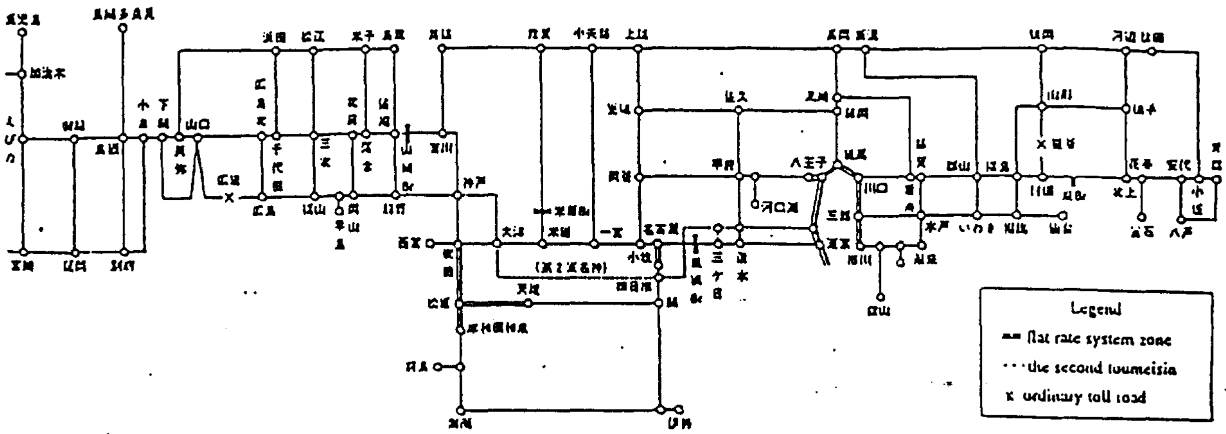

Fig-B4 Express Way Network in Japan

Where there is a loop within the network, distance-based tolls are collected by writing transition information on toll tickets at check barriers on main tracks on the expressway. A tapering distance rate system providing discounts according to the total travel distance is adopted for vehicles traveling long distances to receive favorable discounts.

In order to collect same tolls as those for vehicles without ETC equipment even after ETC system introduction, route-point information must be input at check barriers on maiexpressway tracks. This route-point information amounts to about 700 bits, which is not negligible in the total amount of information for the ETC.

B.4 Extension to Include Various Discount Services

It is natural to provide different toll rates for different sizes of vehicles. In addition, various services such as " round trip discount service" will be introduced.

To provide these services, RSUs (roadside units) will read from OBUs (on-board units) such information as validity periods, previous travel sections and several past travel sections to determine the discount amounts.

For this reason, the actual information volume transferred from the OBU to RSU at the toll gate where a driver pays his/her toll will exceed about 2,000 bits.

B.5 Ensuring DSRC Reliability in Large-sum Toll Collection

The one-way toll for a large-sized motor vehicle driving from Tokyo to Kagoshima, the southernmost end of the expressway network in Japan, amounts to as much as ¥73,000 (US$689), which is a fairly large amount. For errorless DSRC communication of this toll data, it is assumed that the maximum error rate of radio communication between a vehicle and a toll gate RSU must be kept within 10^{-6} or less.

To meet this requirement, the number of frame re-transmissions at a time due to a bit error is set to 4 in the design. About 40% is, therefore, necessary as an addition to the required transmission amount in this case.

B.6 Extension to Other ITS Systems

Two-way DSRC communication systems using microwave can be used for the "two-way navigation system" for traffic management, "specific vehicle management system" for route management for vehicles carrying dangerous substances and especially large vehicles, and "commercial vehicle operation system" (CVO) for assisting of public transportation means, bus and freight truck operations in addition to the "ETC system".

DSRC standardization is naturally required for these systems. Shared use of on-board units will ensure system feasibility by only adding the application software.

In Japan, other than the ETC system is still in the conceptual design stage and details of individual systems are not clear at present. When considering the introduced VICS that is similar in concept, the amount of information for communication between the RSU and each individual vehicle is predicted to be 20 to 40 Kbits.

The reason is that the LDRG (Locally Determined Route Guidance) searching routes on the vehicle side will very probably be first adopted as a system for route guidance in Japan.